PROCESS FOR THE EVALUATION OF SIGNALS IN AN SAR/MTI PULSED RADAR SYSTEM

BACKGROUND AND SUMMARY OF THE INVENTION

[0001] This application claims the priority of German patent document 103 28 279.3, filed June 23, 2003 (PCT International Application No. PCT/DE2004/001260, filed June 17, 2004), the disclosure of which is expressly incorporated by reference herein.

[0002] The invention relates to a process for the evaluation of the received signals in [[an]] a SAR/MTI pulsed radar system ~~according to the preamble of Claim 1~~.

[0003] ~~By means of~~ Synthetic Aperture Radar/Moving Target Indication (SAR/MTI) pulsed radar systems, can be used both to acquire SAR images ~~can be taken, on the one hand, and, on the other hand,~~ and to identify moving targets ~~can be identified~~ in the ~~taken SAR~~ acquired images. Figure 1 shows the pulse sequence of a transmitted signal of [[an]] a SAR/MTI pulsed radar system. Because of the different illumination times~~, which~~ that are required ~~for achieving~~ to achieve a high resolution ~~in the case of~~ with the respective evaluation ~~method~~ methods, the pulse repetition frequencies of the transmitted SAR and MTI pulses ~~deviate~~ differ considerably ~~from one another~~. For [[an]] a typical SAR evaluation ~~with a resolution of up to 1 m~~, an illumination time T_SAR of ~~up to 30 60s is~~

~~required~~ more than ten seconds is possible. However, the illumination time T MTI of a ground area for identifying and tracking moving targets normally amounts to 100 [[-200]] ms.

[0004] Figure 2 shows [[the]] a received echo pulse sequence which essentially is a superimposition of SAR and MTI echo pulses. In ~~the case of~~ known SAR/MTI radar systems, the signal evaluation takes place such that the ~~taking~~ acquisition and ~~generating~~ generation of SAR images and the analysis of the SAR images by means of MTI processes for identifying moving targets, take place ~~successively with respect to~~ in time sequence. Normally, [[an]] a SAR image is ~~taken~~ acquired first, and ~~which~~ is subsequently examined in an MTI process with respect to moving targets.

[0005] ~~A simultaneous~~ Simultaneous analysis of the signals in [[an]] a SAR and an MTI process can therefore be carried out only ~~be carried out~~ at great technical ~~expenditures~~ expense. For known processes for evaluating signals in SAR/MTI radar systems, the received signal is divided into two ~~almost~~ approximately identical components, and one part of the signal ~~being~~ is fed to a device for [[the]] SAR signal evaluation, while the other is ~~and another part of the signal being~~ fed to a device for [[the]] MTI signal evaluation. In this case, however, it is disadvantageous that the radar system, particularly the radar antenna, comprises a large number of constructional elements, and requires high technical ~~technically requires high~~ expenditures ~~for its implementation~~. This results in additional disadvantages with respect to the considerable weight of the

antenna. Another disadvantage is the large dimension of the antenna, which makes it difficult to integrate ~~the antenna~~ it in a flying device.

[0006] It is therefore an object of the invention to provide a process which allows simultaneous evaluation ~~the processing~~ of the received signals ~~simultaneously~~ with respect to the SAR and the MTI, without ~~requiring~~ high technical expenditures.

[0007] Another object of the invention is ~~the creation of~~ to provide an antenna for implementing the process.

~~These objects are achieved by means of a process according to Claim 1 and by means of the antenna according to Claim 5. Advantageous embodiments of the invention are the object of subclaims.~~

[0008] ~~According~~ These and other objects and advantages are achieved by the method and apparatus according to the invention, in which, in the received echo pulse sequence of the received signal, each pulse ~~, corresponding~~ that corresponds to an integral multiple of an integral ratio of the pulse repetition frequency PRF_MTI of the transmitted MTI signal to the pulse repetition frequency PRF_SAR of the transmitted SAR signal, and which is received after a transmitted SAR pulse, is evaluated in [[an]] a SAR process. According ~~, and, according~~ to the invention, the remaining pulses of the received echo pulse sequence ~~of the received signal~~ are evaluated in an MTI process, ~~in which case~~ and the pulse for the MTI signal processing which is absent as a result of the

SAR signal processing, is reproduced by means of an interpolation ~~methods~~ method.

[0009] Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

~~The invention as well as advantages of the invention will be explained in detail in the following by means of drawings.~~

[0010] Figure 1 ~~is a representation of~~ illustrates an example of a transmitted pulse sequence of an SAR/MTI radar system with transmitted SAR and MTI pulses;

[0011] Figure 2 ~~is a representation of~~ shows an example of an echo pulse sequence of an SAR/MTI radar system, with transmitted SAR and MTI pulses;

[0012] Figure 3 is ~~a representation of a first example of~~ a schematic block diagram of an antenna arrangement according to the invention;

[0013] Figure 4 is ~~a representation of a second example of~~ a schematic block diagram of another embodiment of an antenna arrangement according to the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0014] As ~~described above,~~ shown in Figure 1, ~~is a view of an example of a transmitted pulse sequence of an SAR/MTI radar system with transmitted SAR and MTI pulses. Because~~ because of the lower pulse repetition frequency of the transmitted SAR pulse ~~with respect~~ relative to a transmitted MTI pulse, the emission of [[an]] a SAR pulse takes place only after each fifth MTI pulse. (That is, ~~5 being~~ the ratio of the pulse repetition frequency PRF_MTI of the transmitted MTI signal to the pulse repetition frequency PRF_SAR of the transmitted SAR signal is five.) [[.]] In the time window between the transmitted pulses, the radar system is switched to reception.

[0015] ~~As an~~ An example of [[,]] the echo pulse sequence [[of]] resulting from a transmitted signal is illustrated in Figure 2, which ~~. The illustration~~ shows a superimposition of SAR and MTI echo pulses. The pulse received in the time interval marked by reference number 1 in Figure 2 is evaluated by means of a known SAR process. According to the invention, the MTI pulse that is lost in ~~the process~~ this manner is reproduced by an ~~means of an~~ interpolation ~~process. Such an interpolation~~ process ~~is known~~, in a manner that will be readily understood by those skilled in the art. One such interpolation process is described, for example, [[from]] in Joseph Salzmann et al., "Interrupted Synthetic Aperture Radar (SAR)"; IEEE AESS Systems Magazine, May 2002, Pages 33-39, the disclosure of which is incorporated by reference herein. (Other known processes may be used, however.) Advantageously, the ratio of the pulse repetition frequency PRF_MTI of the transmitted MTI signal to the pulse repetition frequency PRF_SAR of the transmitted SAR signal can be changed

from one MTI burst to the next MTI burst, and ~~. The~~ distance ambiguities occurring during the MTI signal evaluation can be determined in this manner.

[0016] The pulse repetition frequency PRF_SAR of the transmitted signal advantageously amounts to between 200 Hz and 400 Hz, and the pulse repetition frequency PRF_MTI advantageously amounts to between 2 kHz and 4 kHz. Thus, integral ratios of the pulse repetition frequency PRF_MTI of the transmitted MTI signal to the pulse repetition frequency PRF_SAR of the transmitted SAR signal of ~~5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20~~ five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen and twenty are ~~conceivable~~ possible. Naturally, it is also ~~conceivable~~ possible to set larger ratios by a suitable adaptation of the pulse repetition frequencies PRF_SAR and PRF_MTI.

[0017] Figure 3 is a schematic block diagram of a first special embodiment of an antenna arrangement 2 according to the invention, which ~~The antenna arrangement 2~~ comprises a plurality of transmitting and receiving modules 3 (T/R modules). ~~These T/R modules 3~~ The latter are combined to form a definable number of subgroups 3a. The T/R modules 3 are of ~~applied to~~ each subgroup 3a [[of]] are applied to a common delay link 4, and a [[. A]] definable number of ~~delay links 4~~ the latter are advantageously combined and applied to a common digital receiving unit 5.

[0018] The digital receiving units 5 are advantageously connected with devices 6 for [[the]] digital beam shaping and for [[the]] moving target indication

according to the known ~~STAP process (~~space time adaptive processing (STAP) method. The devices 6 for the digital beam shaping and for the moving target indication are advantageously applied to additional devices 6a for [[the]] SAR and MTI signal evaluation.

[0019] Figure 4 is a schematic view of a second ~~special~~ embodiment of an antenna 2 according to the invention, which ~~. The antenna arrangement 2~~ comprises a plurality of T/R modules 3 ~~which~~ that are combined to form a definable number of subgroups 3a. In this embodiment, a definable number of delay links 4 are combined and applied to an analog network 7 with a definable number of outputs 8 ~~which~~ that are each applied to a digital receiving unit 5[[,]] (particularly, an analog-to-digital converter). The [[, the]] digital receiving units 5 each ~~being~~ are applied ~~by means of~~ to devices 9 for [[the]] SAR and MTI signal evaluation. In this case, the analog network 7 simultaneously generates different narrow-band radiation patterns in different directions.

[0020] The foregoing disclosure has been set forth merely to illustrate the invention and is not intended to be limiting. Since modifications of the disclosed embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed to include everything within the scope of the appended claims and equivalents thereof.